COOK INLET SEABIRD AND FORAGE FISH STUDIES (CISeaFFS) SUMMARY OF 1997 FINDINGS AND ACCOMPLISHMENTS

CISeaFFS ("Sisyphus") was initiated in 1995 as a long-term research project to characterize relationships between seabird population dynamics, foraging behavior, and forage fish densities in lower Cook Inlet— the area in which most seabirds were killed by the *Exxon Valdez* oil spill. CISeaFFS is a collaborative project of the Alaska Biological Sciences Center and the Alaska Maritime National Wildlife Refuge, with major funding and logistic support from the EVOS Trustees under the APEX Project (Alaska Predator Ecosystem Experiment), the Minerals Management Service, the Biological Resources Division of the U.S. Geological Survey, the U.S. Fish and Wildlife Service, the Alaska Department of Fish and Game, and the Institute of Marine Science, University of Alaska, Fairbanks.

METHODS

In 1995, 1996, and 1997, populations, productivity, diets and foraging behavior of 8 seabird species (Common Murre, Black-legged Kittiwake, Pigeon Guillemot, Tufted Puffin, Horned Puffin, Pelagic Cormorant, Double-Crested Cormorant, Glaucous-winged Gull) were studied to varying degrees at three seabird colonies in lower Cook Inlet (Chisik, Gull and Barren islands). Oceanographic measurements, seabird and hydroacoustic surveys, trawls, and beach seines were conducted in core study areas around (<40 km) each colony. In 1996, coastal transects were added to the survey of core areas to increase sampling of the productive nearshore zone. In 1997, we conducted offshore hydroacoustic and bird surveys within the original core study areas established in 1995. Some new sampling methods and experiments on seabird growth and stress were added in 1997. The following summarizes some accomplishments and preliminary findings of the 1997 CISeaFFS field season in Cook Inlet.

OCEANOGRAPHY

The summer of 1997 was notable for an onset of the strongest El Niño event ever observed in the Pacific Ocean (**Fig. 1**). Warm surface waters made their way up into the Gulf of Alaska by July, resulting in sea surface temperatures 2-3 degrees above average (**Fig. 2**). However, surface waters become mixed with deeper, cooler water as currents drive up onto shallow banks around Kodiak Island and into the shallow entrance to the Cook Inlet estuary.

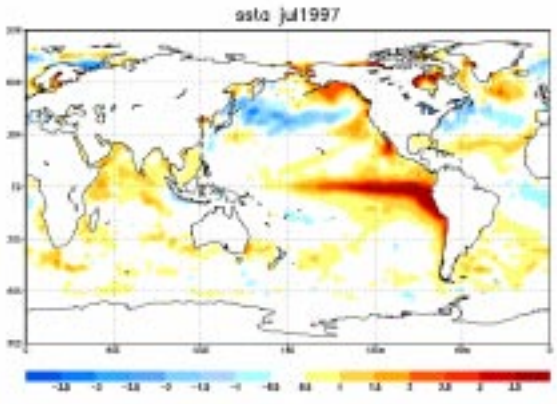

Figure 1. Sea surface temperature anomalies in the world's oceans, averaged over July 1997. Note temperatures 2-3 C warmer in the Gulf of Alaska.

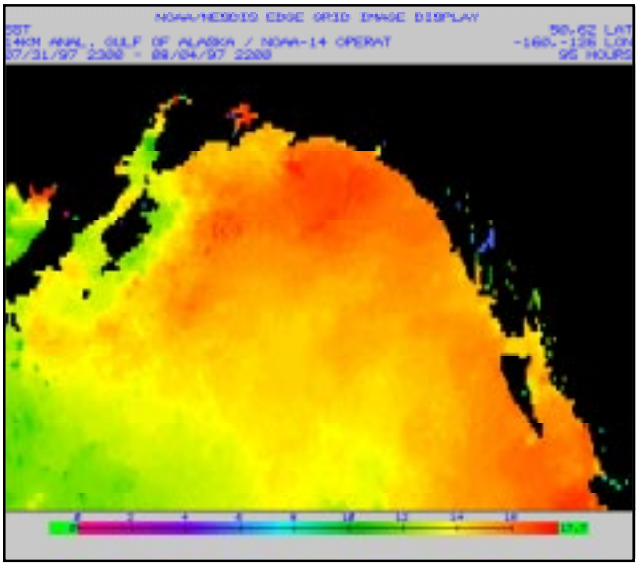

Figure 2. Sea surface temperatures in the Gulf of Alaska, averaged over 31 July - 4 August, 1997. Note cooler temperatures around Kodiak Island and in the entrance to Cook Inlet owing to upwelling and mixing of warm surface layers. These cool areas persisted throughout summer, and may serve to stabilize production in Cook Inlet.

Temperature data loggers which continuously record temperature were again deployed in Lower Cook Inlet. Continuous temperature recordings have now been obtained from Gull Island during summer of 1995, and without a break since March of 1996. We observed almost no difference in sea surface temperatures in Kachemak Bay between 1996 and 1997 (**Fig. 3**). In June, two temperature data loggers were deployed at both Chisik and the Barren Islands. These loggers were retrieved in September. In July, two temperature data loggers were deployed at 10 and 100 m South of Hesketh Island in Kachemak Bay and will record temperature until August 1998. In August, temperature data loggers were re-deployed at Gull Island and Sixty Foot Rock in Kachemak Bay and will record temperature at 5 m until July 1998.

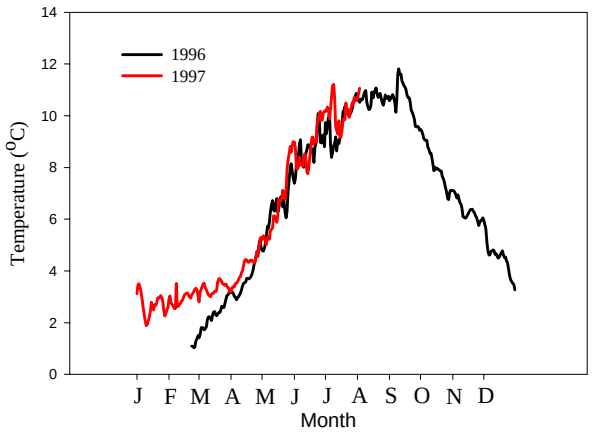

Figure 3. Sea surface (3 m) temperatures in Kachemak Bay, Cook Inlet, from March 1996 to August 1997.

Temperature and salinity (CTD) profiles of the water column were collected in conjunction with mid-water trawls (96 CTD casts), and bottom trawls (40 CTD casts) in Cook Inlet in 1997. Two CTD transects across Kachemak Bay which were established and sampled in May and August 1995, and February, May and August 1996 (Abookire and Norcross, unpub. data) were modified and sampled 3 times in the summer of 1997 (33 CTD casts). On 23 July, temperature and salinity profiles were collected on a CTD transect that was established and sampled in 1996 across Cook Inlet to Chisik Island (7 CTD casts), and on 29 July on a CTD transect that was established and sampled in 1996 across the entrance to Cook Inlet near the Barren Islands (6 CTD casts).

Spatial and temporal patterns in sea surface temperatures in Cook Inlet will be assessed from AVHRR satellite imagery obtained through summer 1997. About 10-12 AVHRR images per day were received beginning in mid-April, and continuing to the present time. The raw images are run through an automated script that clips out the Cook Inlet study area, estimates cloud cover, and drops images that have less then 20% cloud free pixels. To date, 279 AVHRR images have been clipped and archived for 1997. On average only 20-30% of images archived will be of sufficient quality to be useful for large-scale comparison. Additionally, 303 images have been archived from 1996, and 125 images from 1985-1990. The long time-series of images should allow examination of interannual variations in sea surface temperatures of Cook Inlet, including the current and past El Nino events. The high temporal resolution of sampling in 1996 and 1997 will allow us to examine seasonal variations and effects of tides and currents in Cook Inlet on temperature regimes in different areas of the inlet.

NUTRIENTS, PHYTOPLANKTON AND ZOOPLANKTON

A permanent sampling site was established in Eldred Passage (59 30.47, 151 28.22). This site was sampled for phytoplankton and water nutrients on 9 occasions from 15 April to 15 August. Although this site is in a fairly shallow (60 m) and generally well mixed, it was selected for its sheltered location near the Kasitsna Bay Lab. Samples of nutrients and phytoplankton were collected at the surface, and at 5, 10, 25, and 50 m. Although the samples have not been processed, the rise in visible phytoplankton during the last 2 weeks in May suggest we did capture the spring bloom in our sampling. A CTD cast and a vertical zooplankton tow were also conducted at this site on a regular basis. A total of about 40 zooplankton tow samples have been archived for later analyses (volume and species composition).

On 27 June a cross-inlet transect was established between the Homer Spit to the middle of Lower Cook Inlet (12 CTD casts). This transect was designed to traverse 3 distinct bodies of water identified from AVHRR satellite derived sea-surface temperature. At each sampling site samples of nutrients, phytoplankton, zooplankton were taken. Additionally, CTD, fluorometry, and PAR data were collected at all sites. When analyzed, these data should assist in clarifying the relationships between currents, nutrients and primary production, and suggest their direct and indirect influences on higher trophic levels.

FISH SAMPLING

Beach Seines

Between the months of February and August, 217 beach seine sets were conducted in Kachemak Bay. Five permanent study sites were visited once each month until May and then twice each month through summer. Additional sites in Eldred Passage (3) and Seldovia Bay (3) were sampled twice each month throughout summer to assess availability of Pigeon Guillemot food. A total of 102,195 fish were caught in the 217 seines. As in previous years, beach seine catches were dominated by sand lance which comprised 78% of the total catch (compared to 81% and 71% in 1976 and 1996, respectively). Sand lance occurred in 54% of sets (compared to 41% and 51% in 1976 and 1996, respectively). Notable changes in community structure were observed in 1997 (compared to previous

years 1976, 1995, and 1996). Large numbers of first-year capelin (n=5836, 6 % of total catch) were present during the summer compared to only 1 fish in all 3 previous years of study. First-year ling cod numbered 330 individuals and occurred in 15% of seines compared to only 7 fish in all 3 previous years of study. More than 500 fish comprising 10 species have been individually frozen and archived for energetic, stable isotope, and genetic analyses. At Chisik Island, 18 beach seine sets were conducted on 3 different beaches throughout summer. Numbers and composition of fish caught on these sets have not been fully analyzed, but catches were dominated by salmonids, pricklebacks, and herring. Sandlance were also dug from beaches on 7 occasions from 2 sites. All Chisik fish collections were frozen and archived. Beach seining was also conducted throughout summer at the Barren Islands. No results are available yet, but in general, catches were similar to those in 1996 (i.e., dominated by sand lance), and more cod were taken in 1997.

Sandlance were studied in detail. Otoliths were dissected from 2752 fish to assess seasonal, annual and grographic variation in length-at-age and growth rates. Although 0, 1, and 2- year old fish were most common, some were found to live up to 7 years. The age structure of sand lance collected in mid-water trawls was markedly different (**Fig. 4**) to those collected in halibut stomachs or in the nearshore zone (beach seines and intertidal sediments). Sediments from 89 beach sites in Kachemak Bay were characterized, of which 62 sites were known to be used by sand lance. An additional 12 sediment samples were collected near Chisik Island -- an area of lower sand lance density than Kachemak Bay. Collections by personnel from ADF&G, NOAA, USFWS, and local residents allowed us to characterize beach sediments from sand lance habitats in Prince William Sound (3 sites), Kodiak (1 site), Malaspina Glacier (1 site), and Ninilchik (1 site).

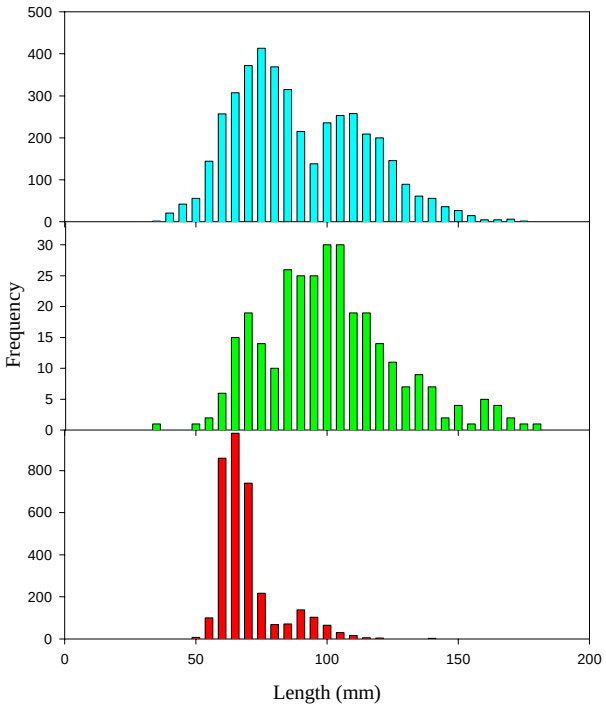

Figure 4. Length frequencies of Pacific sand lance collected from beach senes and sediments (Top), halibut stomachs (Middle), and mid-water trawls (Bottom).

Mid-water Trawls

From 20-25 June, a modified mid-water herring trawl was used from the ADF&G vessel R/V Pandalus to catch forage fish in Cook Inlet. A total of 21 stations and 23 tows were fished on hydroacoustic targets detected with a BIOSONICS DT4000 echosounder. In Kachemak Bay, 215 fishes were caught in 8 tows. Stations in Kachemak Bay were dominated in mass by jellyfish. Some juvenile walleye pollock (<50 mm) were also caught. In general, the Kachemak Bay region was low in species diversity. Near Chisik Island, 1033 fishes were caught in 15 tows. Only one hydroacoustic target was located and fished north of Chisik Island, while remaining stations were all south of Chisik. Regardless of tow duration or depth, species composition was mixed near Chisik with the majority of catches consisiting of Pacific herring, longfin smelt, Pacific sandfish, snailfishes, eulachon, salmonids, and Pacific sand lance.

From 19 July to 2 August, mid-water trawls were again conducted in Cook Inlet from the R/V Pandalus (**Fig. 5**). A total of 43 stations and 50 tows were fished on hydroacoustic

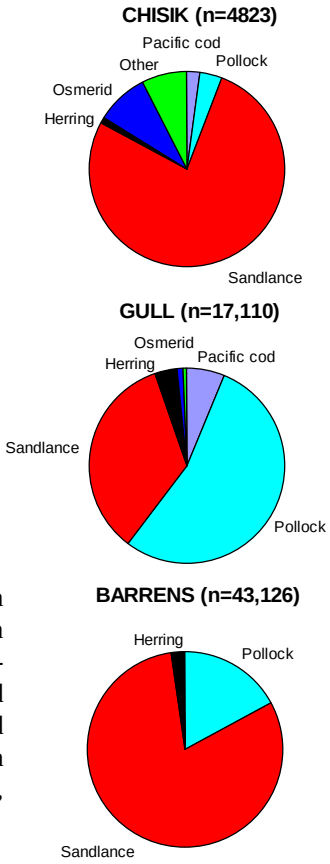

Figure 5. Forage fish species composition in catches from mid-water trawls around Chisik, Gull and Barren islands in lower Cook Inlet, during July 1997.

targets. In Kachemak Bay, 17,110 fishes were caught in 22 tows, at Chisik 4,823 fishes were caught in 11 tows, and at the Barrens 43,126 fishes were caught in 17 tows. Kachemak Bay catches were dominated by walleye pollock and Pacific sand lance. Pacific herring, and Pacific cod represented < 10% species composition. Fish schools at Chisik were consistently mixed with Pacific sand lance, longfin smelt, walleye pollock, salmonids, Pricklebacks, Pacific cod, and Pacific sandfish. Near the Barren Islands walleye pollock was most abundant. At the Chugach Islands (nearshore Barrens area) Pacific sand lance were the dominant species with juvenile Pacific herring also present in the tows. For the entire Barren Island region, Pacific sand lance dominated the species composition. More than 900 fish specimens, comprising 9 species, were frozen and archived for later analyses of energetics and stable isotopes.

In July and August, Issacs-Kidd mid-water trawls were conducted in Kachemak Bay from the R/V David Grey. A total of 15 stations and 19 tows were fished in conjunction with hydroacoustic surveys. Jellyfish, walleye pollock and sand lance were the most abundant species captured. It was difficult to assess the efficiency of the net. The net was lost when the towing cable snapped on August 7.

Benthic Trawls

To assess the species and abundance of benthic fishes within foraging range of Pigeon Guillemot colonies in Kachemak Bay, bottom trawling was conducted at 10 stations on 3 July, 14 July, and 6 August. The 10 stations were located in Halibut Cove, Peterson Bay, China Poot Bay, Neptune Bay, and Eldred Passage. These sampling sites were originally established and sampled in August 1996. In addition, 3 new stations were established and sampled on 17 August near the Pigeon Guillemot colony in Seldovia Bay. To continue monitoring of juvenile flatfishes in Kachemak Bay, bottom trawling occurred on 17 and 18 August at 7 stations near MacDonald Spit. These 7 stations and 33 others were previously sampled in September 1994, May and August 1995, and February, May and August 1996.

Cast Nets

Throughout the summer, cast-netting was conducted near feeding flocks to opportunistically sample fish schools being directly preyed upon by seabirds. Cast netting was effective in capturing forage fishes, especially Pacific sand lance.

Pair Trawl

On 27-28 August the R/V David Grey and M/V Sandlance fished a Kodiak pair trawl near Hesketh Island. The net appeared to fish well, but: i) two boats and six people are needed to pair trawl, ii) towing speed can not exceed 1 knot, and fish probably avoid the net, iii) the pair trawl is designed to fish surface schools, which must first be located with hydroacoustics; and consequently fish may scatter or dive after the boat passes over them. This trawl may be more useful at night, when fish move towards the sea surface.

Underwater Video Camera

An underwater video camera was tested in three ways. First, the camera was towed from a downrigger, but even at boat speed of greater than 1 knot the camera was moving too fast for the images to be clearly seen on the monitor. This method may work best in big schools of fish. Second, the camera was mounted on a pole and manually placed in the water when the boat was in neutral. The camera was easy to maneuver and had clear resolution. This method is better than towing for shallow fish schools (e.g., under bird feeding flocks). Third, the camera was held by a SCUBA diver. The image was very clear and diver lights enhanced range of visibility. This method worked very well and fishes were identifiable from the recordings. The camera is a useful tool to identify fish on a diving transect, characterize benthic habitat, and view sediment types.

Scuba Diving

A pilot study was conducted using SCUBA diving observations to quantify demersal forage fish in the vicinity of 2 Pigeon Guillemot colonies in Kachemak Bay. Protocols designed for sampling guillemot and otter food availability in Prince William Sound were employed. Preliminary inspection dives were conducted in mid-July. A total of 20 line transects were conducted around guillemot colonies at Moosehead Point (10) and Seldovia Bay (10) in August. Species diversity and abundance varied considerably among sites (**Fig. 6**). For example, one transect in Seldovia yielded a density of 44 Lumpenus (spp.) in a 5m section of transect,

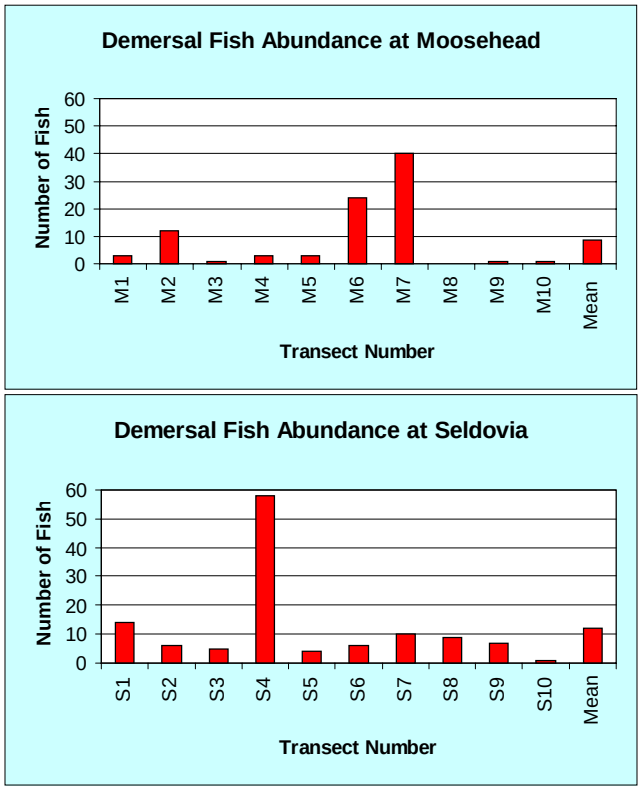

Figure 6. Nearshore demersal and benthic fish densities recorded on diving transects conducted near Pigeon Guillemot colonies at Moosehead Pt. and Seldovia Bay.

while just across the bay only 4 fish were observed on the entire transect. Near the Moosehead Point colony, one transect yielded 19 gunnels, and near China Poot spit, about 100 sand lance erupted from sandy substrate on transect. In total, 11 species were identified at Seldovia and 12 species at Moosehead. However, only 5 species were present in both areas: Myoxocephalus sculpins, gunnels, kelp and white-spotted greenlings, and pacific

Halibut Stomachs

A total of 1408 halibut stomachs (775 with food) were examined from fish caught in local sport fisheries between May and August of 1997. A total of 3252 prey items were identified, comprising 30, 11 and 10 invertebrate, forage fish, and non-forage fish species, respectively. Invertebrates (mainly pygmy cancer and decorator crabs)were the predominant prey (65% of total). Forage fish comprised 26% of the total prey items, of which sand lance was the dominant species. Non-forage fish comprised the remaining 9% of prey.

Hydroacoustic Surveys

Most at-sea hydroacoustic surveys were conducted from the R/V Pandalus, a 23m stern trawler operated by ADF&G. On the first Pandalus cruise (20-25 June), a general survey of Kachemak Bay and waters near Chisik Island were conducted over 6 days. This was a shakedown cruise to test the BIOSONICS DT4000 hydroacoustic equipment, and to refine the mid-water trawling methods. On each day, a search was made for significant hydroacoustic signs of fish. When found, these schools were fished with the trawl, and another hydroacoustic record of schools was taken as schools were trawled. In total, 30 hydroacoustic files were archived while searching, and more obtained during the 23 trawls for fish. CTD casts (39) were taken at the beginning and end of most tows. No bird observations were made during this cruise.

On the second R/V Pandalus Cruise (19 July - 8 August) all nearshore and offshore transects (ca. 1200 linear km) that were established in 1995 and 1996 in core study areas of Kachemak Bay, Chisik Island, and the Barren islands were surveyed hydroacoustically and with mid-water trawls. Transects were broken into segments as determined by the need to stop and trawl significant fish aggregations. Most of the transects were completed from the R/V Pandalus (15 days), but some nearshore transects were completed with the R/V David Grey (5 days). The transects are broken into 100 acoustic data files, and there are 51 fishing files and 2 searching files, for a total of 153 hydroacoustic data files for the cruise. Good hydroacoustic data were obtained on most of the common fish species caught by trawls (see Fish summary). Bird observations were recorded for all transects and during all trawls using DLOG, an automatic bird data entry program with Rockwell GPS position data for each observation. A CTD cast was usually made after every tow. On the few occasions when we fished an area more than once, we did not duplicate the cast. An additional 13 casts were made along 2 transects across the inlet, for a total of 60 CTD casts. All accessible hydroacoustic files have been echo-integrated and saved as bitmaps. All transects, trawl locations and CTD casts have been plotted using GIS software (CAMRIS).

In Kachemak Bay, hydroacoustic surveys were conducted from the R/V David Grey on 7 days (7-12 July, 17 July) searching for good fish sign and attempting to catch fish with an Isaacs-Kidd midwater trawl. In total, hydroacoustic data were recorded during 18 search transects, 16 trawls, and 2 cast-netting attempts.

At-sea surveys for Pigeon Guillemots were conducted during the chick-rearing period around 3 colony sites with known nesting birds. Hydroacoustic surveys were conducted concurrently with the bird surveys. In each study area, 5 transects were established, spaced approximately 500m apart. The nearshore transect was located 250m from the shoreline. All guillemots on the water within 250m of the boat were counted and their locations mapped by entering them into the DLOG computer mapping system. Direction of flight was recorded for all flying guillemots. All fish-holding birds were noted, and fish species was recorded when possible.

SEABIRDS

Preliminary analyses indicate that, in general, productivity of seabirds breeding at Gull and Chisik Islands was lower than in 1996 (**Fig. 7**), but similar to that observed in 1995. Other than a slight reduction in productivity, which may simply reflect annual variability, there is little to suggest that the 1997 El Niño had any effect on seabirds in Cook Inlet.

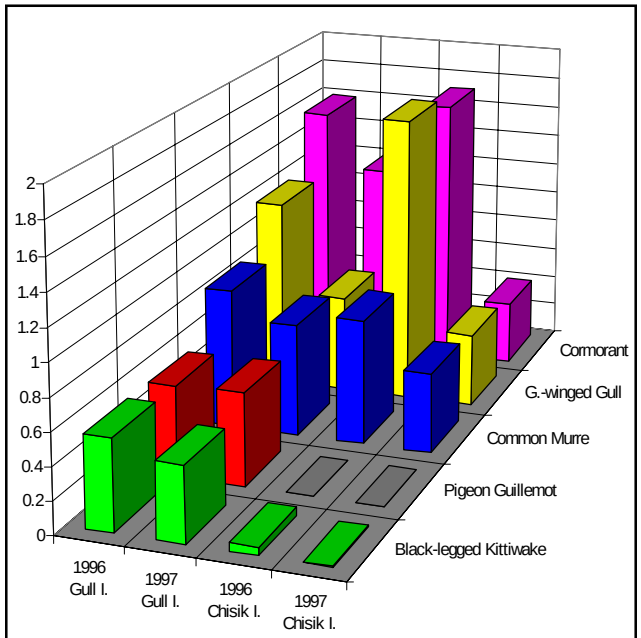

Figure 7. Preliminary comparison of seabird productivity at Gull and Chisik islands between 1996 and 1997. Data are chicks/pair, except for gulls (hatch success).

Common Murres

Field work on Gull Island, Kachemak Bay, began May 29 and continued through early September. Murre productivity was assessed on 9 plots every 1-4 days from 1 July to early September. A preliminary estimate of productivity from 91 nest-sites is 0.7 chicks/breeding pair. Population plots were counted 10 times from mid-incubation through early chick-rearing. The numbers of murres in these plots were similar to 1996 numbers. A whole island census on 23 July yielded a count of 6,068 individuals. Partial and all-day watches of murre attendance, foraging trip lengths, and feeding rates were videotaped on 9 days. Of 327 fish carried by adult murres to their chicks (**Fig. 8**), the most common were smelts (capelin) (37%), sandlance (17%), gadids (17%), and herring (13%). Over half (55%) of fish carried by murres that were not fed to chicks ("display fish") were sandlance. Smelt (17%) and herring (11%) were the next most common display fish. Weight and wing measurements were obtained from 57 murre chicks. Preliminary analyses show chicks gained an average of 4.53±0.76 grams per mm wing length during the linear stage of chick growth (n = 30). Weight and wing measurements were obtained from 38 fledglings after they left the colony. These were banded with a colony color and metal band. Approximately 50 adult murres were banded with metal bands and a unique combination of color bands. In conjunction with other research, most of these birds had some blood taken, hormones implanted, or radios attached. We also collected adult body condition data from every bird handled.

On Duck (Chisik) Island, murre productivity and phenology were observed on 12 plots (including 4 new plots), and 201 nest-sites were monitored. Breeding success was moderate (> 0.5 chicks/pair). First eggs, chicks and fledglings were observed on 24 June, 30 July and 18 August, respectively. Murre attendance and feeding watches (on 10-11 nest-sites) were conducted on 6 days (3 during incubation, 3 during chick-rearing). Watches were synchronized with those conducted on Gull and Barren islands. To assess population trends, 9 plots were counted 10 times during incubation and early chick rearing. Rafting murres were counted on 3 occasions (max: 3500). About 50 chicks were weighed and measured at 3 intervals during chick-rearing. After fledging, 117 chicks were captured, weighed and measured at the base of breeding cliffs (and then released at sea). More than 600 fish were observed being delivered to chicks (**Fig. 8**). Of 12 species identified, smelt (62%), sandlance (17%), and salmon (15%) comprised 94% of the diet. Adult murres (10) were collected to examine stomach contents and to analyze tissue for stable isotope ratios. A total of 131 adults were banded with color and metal bands.

Few preliminary data are yet available from the Barren Islands, but in general, murre productivity in 1997 was similar to that observed in 1996 (Art Kettle, pers. comm.). Productivity and phenology were studied as per protocols established this spring, and observations of attendance, feeding rates, and chick meal composition were synchronized with those at Chisk and Gull islands. Chick diets were similar to last years', and comprised largely of capelin. Population censuses were completed as per protocols. About 100 murre fledglings were captured, weighed and measured.

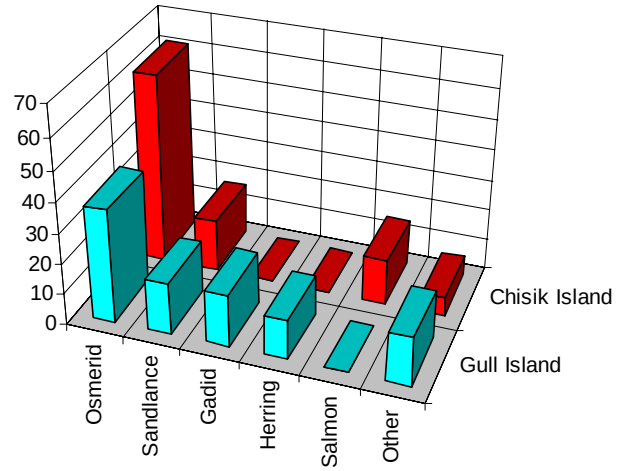

Figure 8. Diet composition (% of total numbers) of Common Murre chicks on Gull and Chisik Islands during summer, 1997.

Black-legged Kittiwakes

On Gull Island, kittiwakes were studied from 1 June to 29 August. Productivity was monitored on 11 plots (26-37 nests/plot) to establish phenology and to determine laying, hatching, and fledging success. Plots were checked every three days from pre-laying to fledging. During peak lay and peak hatch, plots were checked almost every day. Two productivity index counts were conducted to calculate overall kittiwake productivity on Gull Island. All nest structures (>4000) were counted during incubation and all chicks were counted during late chick rearing. Results were 0.46 chicks per nest for Gull Island, and 0.21 and 0.04 chicks per nest in two plots on 60' Rock. Individual birds and nests were counted 10 times in 12 population plots from mid incubation to mid chick rearing. A total of 56 adults were captured, measured, and banded with metal and unique color bands. Dawn-to-dusk feeding and attendance watches were conducted on 30 separate nests during chick-rearing. Chick meals were collected both opportunistically and by inducing regurgitation. Meals were collected the day before, the day of, and the day after feeding and attendance watches. A total of 78 chick meals were obtained, over half of which were complete meals. In addition, 20 adult regurgitations were collected opportunistically, and 10 adults were collected to examine stomach contents and stable isotope ratios of tissue. Chick growth rates were obtained from 38 broods of known-age chicks. A total of 43 chicks were measured 3-8 times until fledging.

On Duck (Chisik) Island, kittiwake productivity and phenology were observed on 10 plots (1 new in 1997), and 147 nests were monitored regularly (mean clutch size: 1.49

eggs/nest; hatch success: 0.43 chicks/egg; overall productivity: 0.014 chicks/breeding pair). First chicks were observed on 5 July, and first fledglings on 7 August. On index plots visited twice, 13,341 nests produced only 59 chicks, yielding a productivity estimate of 0.004 chicks/ pair. Attendance and feeding observations were limited by low numbers of chicks (3 all-day watched of 2-3 nests). To assess population trends, 8 plots were counted 10 times from mid-incubation to mid-chick rearing. Food (regurgitation) was collected from 8 chicks and 12 adults. Adults (10) were also collected to examine stomach contents and to analyze tissue for stable isotope ratios. A total of 13 chicks were weighed and measured every 4 days until they fledged or disappeared. A total of 69 adults were banded with color and metal bands.

Few preliminary data are yet available from the Barren Islands, but in general, kittiwake productivity in 1997 was much lower than that observed in 1996 (Art Kettle, pers. comm.). Productivity and phenology were studied as per protocols established this spring, and observations of attendance and feeding rates were synchronized with those at Chisk and Gull islands. Chick regurgitations were collected as per protocols, but sample sizes were limited by the small number of chicks available. Population censuses were completed as per protocols.

Pigeon Guillemots

Pigeon Guillemot populations in Kachemak Bay were censused using 2 methods. The first involved a thorough survey of the entire south shore of Kachemak Bay between 9-12 June. The second involved repeated (9) surveys on different days of 16 colonies during times of maximum attendance within the incubation period (30 May - 26 June). Populations were comparable to those observed in 1995 and 1996. Reproductive success was monitored at 80 nest sites, and a preliminary maximum estimate of breeding success is 0.57 chicks/breeding pair. A total of 84 chicks were weighed and measured at least once, and 48 chicks were followed to fledging. All-day watches to assess feeding rates and diet composition were conducted on 11 days at 5 different colonies. Provisioning rate data were collected from 33 nest-days of observation of known-age broods, 939 chick meals were observed, and 48 chick meals were collected. Schooling fish (sandlance) in diets ranged from 0% in Seldovia Bay colonies to 76% at Moosehead Point. Prey abundance was measured independently from beach seines at 11 sites around 4 colonies every 2 weeks from early June to early September. Bottom trawls were conducted at 10 sites around 4 colonies on 3 occasions during chick-rearing, and 3 new trawl sites were established in Seldovia Bay and sampled once. Benthic fish were sampled by divers on 10 transects at both Moosehead Point and Seldovia Bay during late chick rearing. Schooling fish were sampled on hydroacoustic surveys around guillemot colonies at Moosehead Point (3 surveys), and Yukon Island and Seldovia Bay (2 surveys each). The distribution of Pigeon Guillemots was also recorded on these surveys. Blood samples were collected from 39 chicks for the EVOS Trustee Nearshore Vertebrate Project. Of these, complete two-sample series were obtained from 31 chicks. Also, 10 web punches and 23 fecal samples were taken from chicks. Blood samples, web punches, Elisa assay swabs, and morphometrics were obtained from 5 adults. A time-series of blood samples from 10 chicks, and from one adult were taken for studies of stress (corticosteroid) response.

Glaucous-winged Gulls

On Gull Island, Glaucous-winged Gulls began laying eggs on or before June 1. Productivity plots were checked every 2 - 10 days through June and July. We monitored 60 nests in 5 plots with 8 - 19 nests in each. Mean hatching success in these plots was 0.61 ±0.07 chicks hatched per egg laid. The median hatch date was July 1. Mean clutch size was 2.46 ±0.17 eggs per nest. We counted 1222 individuals on the island during one census in mid-June. On Duck (Chisik) Island, Glaucous-winged Gulls (n=24 nests) had a mean clutch size of 2.33 eggs/nest, and a hatching success of 0.46 chicks/egg. First chicks were observed on 22 June, and median hatching was on 27 June. Population plots (2) were counted 10 times. Chick regurgitations were obtained from 8 chicks.

Puffins

On Duck (Chisik) Island, 60 Horned Puffin nest sites were followed every 4 days from incubation, and 13 more nests (chicks) were found at later dates. First chicks appeared between 17-21 July. Diurnal attendance patterns were studied on 3 days, and seasonal attendance patterns assessed from daily counts between 27 June and 4 September. Populations plots (6) were counted daily from 14 June to 14 August, and 6 whole island censuses yielded a maximum count of 2335 puffins. About 100 chick meals were obtained from netting adults, pick-ups, and visual identifications. Chick feeding rates were obtained from all-day watches (3) of 5-7 nest-sites. Chick growth rates were obtained from 17 chicks measured every 4 days. On Gull Island, individual growth rate data were obtained from 5 Tufted Puffin chicks. Some puffin chick meals and phenology data were collected opportunistically from sightings of adult puffins carrying fish. On the Barren Islands, Tufted Puffin breeding success was much higher than last year, and diets contained more sandlance than in previous years (Art Kettle, pers. comm.).

Cormorants

On Gull Island, 20 Pelagic Cormorant nests were monitored every 3-17 days throughout the summer. Productivity in 13 nests was 1.23 ± 0.34 chicks per nest. An index of productivity from all 70 nests on the island was 0.93 chicks per nest. The breeding population was estimated at 140 individuals based on a census of nests in late June. On Duck (Chisik) Island, only 3 of 15 active Double-crested Cormorant nests produced chicks (6 total). No Pelagic Cormorants or active nests of this species were observed all summer.

ADULT SURVIVAL AND RADIO TELEMETRY

A pilot project was initiated to assess the potential for using radio telemetry as a means of measuring annual survival in murres. We surgically implanted transmitters into 20 murres; which fell into 4 groups of 5 birds each based on transmitter and surgery type (subcutaneous or abdominal transmitter, external or internal antenna). Radios may last for 1-2 years after implantation, and so tagged birds may be readily detected in subsequent years with relatively little search effort. Furthermore, foraging and attendance information can be obtained from radio-tagged birds during the breeding season. We also attached radios externally to 3 murres and 6 kittiwakes at Gull Island. The immediate survival and success in detection of birds following attachment or implantation was evaluated by i) searching for color-banded individuals at the colony, ii) using a Data Collection Computer (DCC) and permanent receiver at Gull Island to continuously scan for radio-tagged birds, iii) used triangulation methods from boats and land to locate birds foraging at sea, and, iv) searched for birds at sea in an airplane equipped with a receiver and GPS tracking program. In general, the birds with surgical implants appeared to tolerate well the immediate effects of surgery, and some were sighted back on their nests within a day. Many birds have been detected with radio receivers, but as most of this work was conducted in August, we are still evaluating results.

At the same time, and for evaluation of future potential in measuring adult survival as well as logistic problems, we initiated traditional color banding on both Chisik and Gull islands. Logistics of capture and banding were difficult on both islands, but eventually techniques were refined, allowing us to color band a total of about 180 Common Murres and 125 Black-legged Kittiwakes. A further problem with banding is that a considerable effort is required in subsequent years to re-sight banded birds. For radio-tagged and banded birds, next year will reveal the relative merits of these methods for assessing adult survival.

DIET QUALITY AND CHICK GROWTH

Controlled studies on the effects of diet quality on growth and development of kittiwake and puffin chicks was completed at the Kasitsna Bay Lab in Kachemak Bay. This marks the final field season for this experimental study. A total of 24 Black-legged Kittiwake chicks were collected at colonies in Kachemak Bay and raised in captivity. The birds were divided into four diet treatment groups, which were fed different amounts of walleye pollock or Pacific herring. Diets were constructed to assess the growth response of the chicks to equal biomass and equal caloric rations of each fish species, which are very different in their lipid and protein densities. Based on lab studies prior to the field experiment, we calculated that calorically, rations of 100g herring/day = 193g pollock/day, and that 100g pollock/day = 52g herring/day. Our *a priori* hypothesis was that growth performance of chicks is affected by lipid:protein ratios of their diets. To assess assimilation efficiencies, fecal samples were collected at regular intervals for all birds in the study. In addition, blood was collected from each bird to measure corticosteroid (stress) levels of chicks on different diets (Sasha Kitaysky). From the Barren Islands, 30 Tufted puffin chicks were collected and raised in captivity at Kasitsna Bay. At the Barrens, blood was also collected from 5 adult puffins for stress studies. Diet treatments of nestling puffins were similar to those of kittiwakes. A fifth treatment was added to investigate the effect of temporal variability in the amount of food delivered to chicks on growth and development.

Preliminary results indicate that kittiwake chicks grow and develop faster on the high lipid, herring food source, given equal biomass or equal caloric rations (**Fig. 9**). Tufted Puffin chicks show a difference in growth and development among equal caloric rations of the high lipid and low lipid fish. Birds receiving the low lipid yet greater biomass ration are growing faster than the birds receiving the high lipid yet low biomass ration. It appears that lipid content may not be as important to Tufted Puffin chicks so long as adequate calories and biomass are provided. Birds within the study group that have their rations adjusted temporally seem to grow as well as birds that receive the same diet on a regular schedule. Later analyses in the laboratory at Oregon State University will include proximate analysis of the chicks to determine body fat reserves and bomb calorimetry of fecal samples to determine assimilation efficiency.

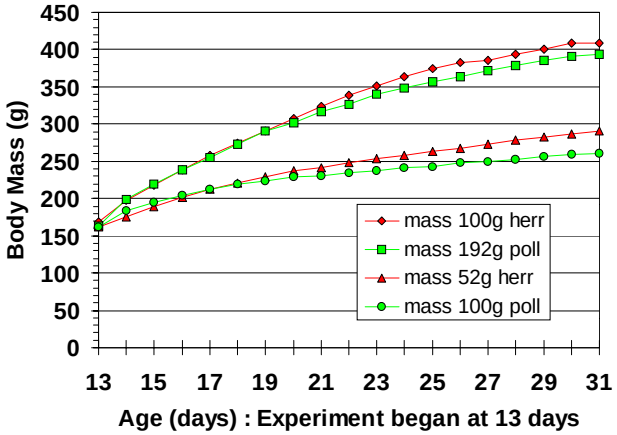

Figure 9. Body mass growth of captive Black-legged Kittiwake chicks fed on iso-caloric diets of Herring and Pollock under adequate (top 2 lines) and marginal (bottom 2 lines) feeding regimes.

PHYSIOLOGICAL STRESS AND FOOD SUPPLY

Although “food stress” is a term used widely to describe situations in which seabirds have difficulty obtaining food, the biochemical response of seabirds to fluctuations in food

supply has never been studied. In 1997, we investigated the physiological status of free-living seabirds in food-rich (Gull Island) and food-poor (Chisik Island) environments. To measure stress, we used a well-documented technique--the rise in blood concentration of stress hormones to a standardized stressor: capture, handling and restraint. Birds that are *not* stressed prior to handling exhibit a classic response (**Fig. 10**): corticosteroid concentrations in the blood increase rapidly during the first 30 minutes after capture, and level off at some higher concentration as the bird continues to be restrained. Birds that are *already* under chronic stress prior to capture also respond by releasing corticosteroids into the blood, but these hormones are rapidly soaked up by receptors that have been induced by previous exposure to chronically high corticosteroid levels. Hormone levels return rapidly to pre-capture levels in these birds (**Fig. 10**).

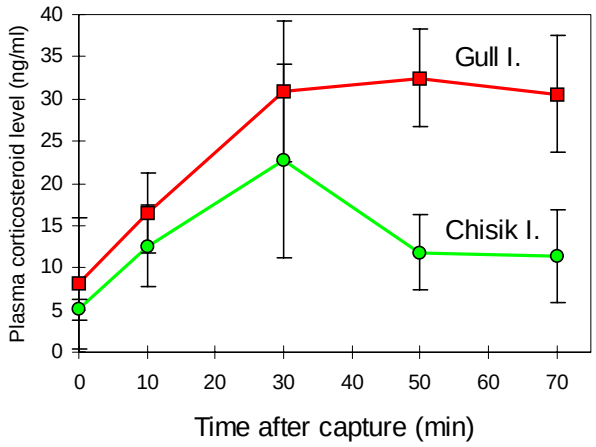

Figure 10. Rise in blood concentration of corticosteroids in response to a standardized stressor: Adult Black-legged Kittiwakes at Gull Island (food-rich) and Chisik Island (food-poor) captured during the early incubation period.

Several specific questions were addressed during the field season: **(1)** Are baseline levels of corticosterone high in seabird populations under nutritional stress? Preliminary results indicate that baseline corticosterone levels (those observed at time 0 after capture) were not significantly different among adult Black-legged Kittiwakes that were captured at Gull and Chisik islands during early incubation (**Fig. 10**). Similar results were observed with Common Murres. **(2)** Do chronically food-stressed seabirds respond differently to the additional artificial stress of capture and restraint? The kittiwakes from Gull Island (food-rich) showed a classic *unstressed* hormone response, while those from Chisik (food-poor) responded in a way that indicates they were *already stressed* prior to capture (**Fig. 10**). Kittiwakes at Chisik subsequently failed to produce chicks, while those at Gull fared normally (**Fig. 7**). Common murres sampled during incubation showed no difference in reponse among colonies, and both populations exhibited normal breeding success. Kittiwakes and murres were also sampled during their chick-rearing periods to determine whether stress among species or colonies increased later in the breeding season. **(3)** Is the rate at which food is provisioned to chicks affected by stress? Manipulative, controlled experiments were conducted on both kittiwakes and murres. In separate experiments, adults and chicks were implanted with hormones to artificially increase blood hormone levels. Begging, feeding and attendance behavior were then quantified. Results were unequivocal and highly significant. Implanted chicks nearly doubled their rates of begging for food, and (untreated) adults responded by feeding them nearly twice as often as control birds. Implanted adults spent far more time away from colonies (presumably foraging), but did not increase their rate of food delivery to (untreated) chicks. **(4)** Does food quality affect stress levels in growing chicks? Baseline and stress-response levels of corticosteroids will be examined in 30 kittiwake and 30 Tufted Puffin chicks fed fat-rich (herring) and lean (pollock) forage fish under different feeding regimes (see Diet Quality and Chick Growth, and Fig. 9). Preliminary results of a pilot study in 1996 revealed that kittiwake chicks fed iso-caloric diets of pollock and sandlance were much more stressed under the pollock diet than the sandlance diet. Tufted Puffin chicks were apparently not stressed differentially by diets of varying quality.

RESEARCH TEAM

The following all participated in 1997 CISeaFFS research in the field and laboratory: Alisa Abookire (BRD), Dave Black (BRD), Margie Blanding (USFWS), Brad Congdon (Queen's U.), Paul Desjardins (ADFG), Gary Drew (BRD), Dave Duffy (UAA), Brian Duggin (OSU), Jared Figurski (UCSC), Mike Geagel (UAF), Lilly Goodman (BRD), Celia Hall (USFWS), Ann Harding (U. Sheffield), Greg Hoffman (UCSC), Arthur Kettle (USFWS), Alexander Kitaysky (UW), Roman Kitaysky (BRD), Mike Litzow (BRD), April Nielsen (BRD), Tom van Pelt (BRD), John Piatt (BRD), Jennifer Pierson (OSU), Martin Robards (MUN), Dan Roby (OSU), Marc Romano (OSU), Dave Roseneau (USFWS), Mike Schultz (PRBO), Brian Smith (OSU), Greg Snedgen (USFWS), Suzan Speckman (BRD), Pam Tuomi (BRD), Jenny Wetzel (BRD), John Wingfield (UW), Sadie Wright (UAF), Stephani Zador (BRD). Project Leader for CISeaFFS is John Piatt (BRD).